

Sustainability and Scalability of Digital Tools for Learning: ABRACADABRA in Kenya

Durabilité et évolutivité des outils numériques d'apprentissage : ABRACADABRA au Kenya

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Abstract

This paper explores factors to increase the likelihood that the implementation of ABRACADABRA, a technology-based approach to teaching and learning literacy, endures and expands beyond the initial research. Started as a pilot study in 12 classrooms, the implementation spread to more than 500 primary classrooms over six years in five areas of Kenya. Drawing from research about scalability and sustainability of educational interventions and value-expectancy-cost theory, an exploratory survey was designed to interview a range of actors involved in the software implementation. We used a combination of an a priori and data-driven coding approaches to analyse the narratives. We then built a model exploring the relationship between expectancy-value-cost beliefs and the factors associated with implementation and sustainability. The model explained an important portion of variance in the self-reported intent to use the software with the most significant contributions from policies, professional development, and students. These findings may be useful in the context of low- and medium-income countries where no research-proven principles exist to building sustainable and scalable educational interventions.

Keywords: educational technology; sustainability factors; scaling; Sub-Saharan Africa

Résumé

Cet article explore les facteurs permettant d'augmenter la probabilité que la mise en œuvre d'ABRACADABRA, une approche technologique de l'enseignement et de l'apprentissage de

l'alphabétisation, perdue et s'étende au-delà de la recherche initiale. Commencée comme une étude pilote dans 12 classes, la mise en œuvre s'est étendue à plus de 500 classes primaires sur six ans dans cinq régions du Kenya. S'inspirant de la recherche sur l'évolutivité et la durabilité des interventions éducatives et de la théorie valeur-expectative-coût, une enquête exploratoire a été conçue pour interroger une série d'acteurs impliqués dans la mise en œuvre du logiciel. Nous avons utilisé une combinaison d'approches de codage a priori et axées sur les données pour analyser les récits. Nous avons ensuite construit un modèle explorant la relation entre les attentes-valeur-coût et les facteurs associés à la mise en œuvre et à la durabilité. Le modèle explique une part importante de la variance dans l'intention autodéclarée d'utiliser le logiciel, les contributions les plus significatives provenant des politiques, du développement professionnel et des étudiants. Ces résultats peuvent être utiles dans le contexte des pays à revenu faible ou moyen où il n'existe pas de principes validés par la recherche pour construire des interventions éducatives durables et évolutives.

Mots-clés : technologie éducative ; facteurs de durabilité ; évolutivité ; Afrique sub-saharienne

Introduction

Education has been recognized worldwide as a key component of social systems that enables countries' sustainable development. To date significant progress has been made on bringing education to children. Yet, the global reference targets first set by the Millennium Goals (United Nations, 2000) and by the Sustainable Development Goals (UNESCO, 2015) are not being achieved as fast and effectively as intended. Recent UNESCO reports affirm that the “world is far off track” on attaining international commitments to ensure quality education for all youth (UIS 2019a; UNESCO, 2021a). By 2019, some 483 million children of primary and lower secondary school age lacked foundational reading skills after years spent in the schooling system (UIS, 2019b). The global pandemic has aggravated this learning crisis wiping out gains that the world made over a few decades through education efforts (UNESCO, 2021b). Research on educational practices has generated a rich knowledge base with the potential to improve teaching and learning and to optimize functioning of educational systems. However, for the research-based strategies to have real and widespread impact, they need to be viable in authentic environments of classrooms and schools and at scale. Hence, the UNESCO International Commission on the Futures of Education (2021a) calls for research and innovation to focus on detailing the conditions that lead to scaling effective practices. This paper explores factors that have potential to increase the likelihood that a technology-based approach to teaching and learning endures and expands beyond initial research.

Related Literature

Scaling and Sustainability of Educational Innovations in Developing Nations

Issues of scalability and sustainability in education are not new. The directions taken to study systemic educational improvement include Rogers' Diffusion of Innovation theory (1962), educational change (Fullan, 1982), curricular reform (Goodson et al., 1989), school change (Argyris, 1993), and education systems change (Christensen, 1997) to name a few. The first analysis of challenges involved in producing significant change in instructional quality at scale was prepared by Elmore in 1993. In international development, Myers' influential paper (1984) explained why going to scale is critical in order to have impact on educational policy and programming in countries with limited resources and capacities. Since then, scaling and sustainability of successful interventions have gained substantial traction in the global educational agenda.

However, the ever-growing body of systematic evidence on effective interventions in developing nations' educational contexts tells little about how to make an intervention work for many individuals and for a sustained time (Evans & Popova, 2016; Kim et al., 2020). For instance, the only randomized trial (Bold et al., 2018) focused on transferring a tested intervention on teacher hiring practices to national implementation. It found that the intervention produced higher student learning gains when implemented on a modest scale by a nongovernmental organization rather than the government. Also, Piper et al. (2018) reported a case about bringing a large government-supported pilot to national scale. Following a vertical scaling path, the reading program has been institutionalized through national planning mechanisms and involvement of national and international stakeholders (Piper et al., 2018).

Given a dearth of research on scaling educational innovations, the evidence generated outside education such as industry and agriculture has been tapped for the benefit of educational systems in developing nations (McLean & Gargani, 2019). However, suggesting that this knowledge is far from fully relevant to educational change, the Millions Learning report (Robinson et al., 2016) concluded that bringing to scale quality learning outcomes for children and youth continues to remain an abiding concern.

Further, scaling is only successful when sustainable; the relationship between the two has yet to be clearly articulated. For instance, research on educational change treats sustainability as a pre-condition for scale whether small or large. Coburn (2003) insists that the scale is meaningful over time

only if the implementation can be sustained in the adopting schools. The institutionalization process including rules and regulations and implementation becomes the key in order for the innovation to be integrated permanently into the school structure and culture. Mioduser et al. (2004) underline the importance of the within-school spread. The big challenge in this process is to expand beyond the “islands of innovation” to “comprehensive innovation” that encompasses at least half of the teaching and learning in the school and most importantly affects its entire culture. After all, teachers are more likely to be able to sustain an intervention when it becomes the school’s priority and the activities are aligned with it. This speaks to the existence of an interactive relationship between sustainability and adoption where innovations evolve over time through modifications based on teachers’ needs and beliefs (Dede, 2006). In this process teachers reevaluate the degree and manner to which innovations are implemented, balancing implementation with perceived usefulness, costs, and expectations.

Value-Expectancy-Cost Framework

Based on Shepperd’s (1993) motivational analysis of productivity losses in groups, Abrami et al. (2004) and Wozney et al. (2006) applied expectancy theory to construct a unified view of the diverse issues that influence a teacher’s decision to implement an educational innovation and persist in its use. The Wozney et al.’s (2006) model posits that an educational innovation is more likely to be implemented if its perceived value and the likelihood of success are high, and if the benefits outweigh the costs of implementation. Specifically, a teacher’s decision about whether to implement an innovation depends on how highly they value the strategy, how successful they expect it to be, and how important they perceive the costs of implementation to be. Value assesses the degree to which teachers perceive the innovation or its associated outcomes as worthwhile including benefits to the teacher (such as congruence with teaching philosophy, career advancement), and to the student (such as increased achievement, improved attitudes). Expectancy relates to teachers’ perceptions of the contingency between their use of the strategy and the desired outcomes, and factors affecting these perceptions including internal attributions (such as teacher self-efficacy and skill), and external attributions (such as student characteristics, classroom environment and collegial support). Cost relates to the perceived physical and psychological demands of implementation and operates as a disincentive to innovating and may include class preparation time, effort, and specialized materials.

Influences on Sustainability and Scale

Multiple influences may affect the delicate balance of components constituting teacher motivation to maintain improvements they achieved by implementing an intervention. The literature suggests that factors that influence processes related to implementation and sustainability are attributes of the innovation, those of its users, as well as the features of the environment including those within and outside of the organization (Century et al., 2012).

Having reviewed the experiences of 14 educational programs in low- and middle-income nations, Robinson et al. (2016) implies that the program design, delivery mechanisms, finance, and an enabling environment are the factors of successful scaling. Evaluation research of information and communications technology (ICT)-based educational initiatives in developing countries groups these factors into individual and organizational, technological, economic, and political dimensions (Pouezevara et al., 2014). Individual and organizational dimensions relate to the individual practitioner and school capacity to sustain the intervention, as well as the organizational context encompassing leadership, school community including collegial culture and students, individual and collective capacity, ownership and expectations. Since the capacity of actors involved in implementation vary, careful attention to both training and support is required to meet the existing needs in technical, pedagogical, and content knowledge (Mishra & Kohler, 2006). Technological dimensions are concerned with the ICT needed to bring the educational intervention to teachers and students such as operation of infrastructure and equipment. Economic dimensions refer to costs and economic environment in which the innovation implementation unfolds. Political dimensions pertain to support for the intervention through local and national politics, policies, and individuals.

This paper reports the factors that impact Kenyan teacher's beliefs, attitudes, and motivation to persevere in implementing a technology-based approach for literacy instruction and its potential to endure and expand to new contexts. The participants of this study were involved in the implementation of the software between 2012 and 2018. It started as a small pilot study with 12 primary teachers and their students and spread to more than 500 classrooms in five areas in Kenya (Abrami et al., 2016; Lysenko et al., 2019).

Method

About ABRACADABRA

As part of Learning Toolkit Plus, a suite of five bilingual (English and French) evidence-based and evidence-proven tools designed to build essential educational competencies, *ABRACADABRA (ABRA) software* is an online interactive environment promoting the teaching and learning of English and French literacy skills among youngsters, especially those at risk of school failure (Abrami et al., 2020). Figure 1 reflects the structure of the software. ABRA has three main modules: Students, Teachers and Parents—with the Student or instructional module being the main focus. Using a web browser, teachers and students access the software stored centrally on a server with a username and password. Thus, student activity may be tracked and organized in the form of teacher assessment reports accessible via the Teacher module.

ABRA contains 33 pre-alphabetic, alphabetic, fluency, comprehension, and writing activities of different levels of difficulty that are linked to a multitude of interactive stories of various genres. Students receive meaningful audio-visual feedback as they complete activities, guiding them to the correct answer. Activities are not timed, and children always have access to a help button. The gaming elements of ABRA are many and engage children in reading and writing to increase their motivation. For instance, a mini-game rewards students after they complete an activity. In some activities the game is at the core of their pedagogical structure. ABRA characters are linked to literacy skills; each has a personal story that reinforces the purpose and context of what students do in a specific activity.

The Teacher module contains a wide range of online support materials including lesson plans, teacher guides, instructional videos, and classroom resources. The Parent module offers websites that may be accessed from within or outside of the tool with an array of multimedia materials that help parents support use of the tool at home.

READS, an organized collection of illustrated digital stories from around the world, complements ABRA. The stories are in a variety of languages, including Kiswahili among others. Available in html or PDF formats, stories are catalogued by reading level, theme, language, country of origin, among other criteria. The library is easy to navigate, even for school-age children.

Figure 1

ABRA Structure



Training and supporting teachers of early grades on how to use ABRA to teach literacy is another key component of the intervention. The participating Kenyan teachers are mostly from under-resourced public schools. The teacher professional development (TPD) sessions are led by the local team of experienced trainers who rely on a variety of training approaches to introduce the ABRA

pedagogy. While modelling effective lesson planning, using classroom simulation and feedback for and by the teachers, the trainers support the teachers by offering opportunities for transferable pedagogy through active participation and practice. The teachers are supported by school-based ambassadors (SBA) who are seasoned teachers and users of the software. The SBAs provide in-class support to peers, observe, and review lessons for future improvement. They communicate with the project coordinator to make plans for the follow-up monthly training where teachers reflect on their progress. Once the teachers gain sufficient confidence, the trainers and SBAs often go into the classrooms to observe lessons and give feedback to the teachers. This combination of face-to-face input and practicum-based activity continues cyclically through the implementation phase of the project.

Interview

In order to explore factors influencing the ABRA use based on the existing research, we designed the Sustainability Interview. The funnel format of the interview obtained the interviewees' broad and specific perceptions. The survey was piloted with a handful of individuals involved in the ABRA implementation since the onset of the research project in Kenya. The survey was then adjusted to elicit more specific responses.

The survey begins with two questions about how teachers got involved with ABRA and what they would have done differently to improve the software implementation. Then two broad questions inquire about ABRA's sustainability and scalability.

We consider teachers' expectancy beliefs to be in the larger context of potential influences and often beyond their control. Therefore, the survey explores eight categories of influences including Political Factors, Economic and Technology Factors, Organizational or School Factors, Teacher Professional Development Factors, Software Factors, individual Teacher and Student Factors, and other factors. Each question on the specific factors includes prompts to further probe respondents' thinking. For instance, the software factors question probed into how the ABRA fit with the curriculum, local context of stories and activities, narration and accents, the tool's interactivity, shortcomings, inadequacies, and gaps of the tool.

Sample

Forty-three individuals participated in the interview. Three interviewees participated in both phases of the survey; their pilot interviews were not included leaving 40 respondents in the analysis.

Table 1 shows the categories of respondents where school practitioners were the largest category. Of the 11 teachers, nine were active users of ABRA, whereas two stopped using the tools. Among five school administrators, four were the headteachers in the schools where use of ABRA continued over many years. The ambassadors were all school teachers; two of them were school-based and the other five were roving ambassadors.

Table 1

Categories of Interviewees

Interviewees	Number of Completed Interviews
School Practitioners:	
Head teachers, Deputy head teachers	5
Teachers	11
Ambassadors (master teachers)	7
Partners:	
I Choose Life staff (county coordinators, advisor, coach)	4
World Vision	3
Aga Khan Foundation, Development Network	2
Executive officers	3
Kenya project coordinators	3
Researchers	2

Analyses

After the interviews were transcribed, three respondents were randomly selected and their responses were used to develop a coding system. At this stage, the first author developed the system and elaborated on differences between expectancy, value, and cost statements. The three authors reviewed these codes and the coding system for finalization. Coding was completed with Hyper Research v.3.7.3. In addition to an a priori approach, data-driven codes were also generated. The second coder validated codes and their categorization on 10 randomly selected interviews. The agreement rate evolved from 59% to 85%.

Next, SPSS v.24 was used to quantify and analyze the data. We accounted for each of the factor categories, the sub-questions mentioned by a respondent, and the valence of the response as influencing

the sustainability of the ABRA. Then, the total positive, negative, and neutral responses were cumulated across respondents. Only a single response per category and each subcategory were recorded to maintain the respondent as the unit of analysis. Multiple responses per category or subcategory were combined to reflect the coder's best impression of the respondent's beliefs. Finally, path analysis (AMOS v.26) was run to explore the relationship between expectancy-value-cost beliefs and the specific factors associated with implementation and sustainability.

Results

The findings are reported by the survey questions and followed by the path diagram results.

Reasons for Continuing or Stopping to Use the ABRA

All 40 respondents answered this question; each respondent offered up to 14 ideas. According to the theoretical framework, the ideas were grouped into values, expectations, and costs. The results are shown in Table 2.

Values related to benefits teachers saw after having used ABRA. The values category was the largest with 140 instances. Primarily, these pertained to benefits for their students as follows: they became more motivated (n=14), improved skills (n=12), and developed autonomy (n=12); students' absenteeism reduced (=4). Benefits for the teachers included motivating their students (n=11) and providing an opportunity for improving teaching expertise (n=10). General advantages of ABRA were its fit with the curriculum (n=6), comprehensiveness (=4), and effectiveness for students of various levels and abilities (n=4).

Expectations were categorized in the internal or external attributes in teachers' assigned perceptions. The most frequently reported internal attributions were "if teachers see value in using the tool" or "if the tool is not perceived as an add-on" (n=16); and if teachers are intrinsically motivated (n=10). Curiously, non-teacher interviewees indicated that technology use might be contingent on the teachers' age as younger teachers might be more tech savvy (n=5). Attributions to external sources were more frequent and related to school context: if headteachers are encouraging and do not hamper use (n=23); and if support is accessible (n=13); if electricity is stable (n=12). Expectation of a financial reward was also mentioned (n=4).

Table 2*Summary of Codes by Values, Expectations, and Costs*

Categories (Number of Ideas)	Number of Respondents	Number of Coding References	% of Total Coding References
<i>Values</i>	39	140	
Benefits to students (12)	32	88	62.86%
Benefits to teachers (6)	21	32	22.86%
General benefits (7)	16	20	14.29%
<i>Expectations</i>	39	111	
External attributions (13)	30	61	54.95%
Internal attributions (8)	26	50	45.05%
<i>Costs</i>	36	88	
Psychological demands (5)	7	8	9.09%
Physical demands (16)	35	80	90.91%

Costs related to using ABRA was the smallest set including 88 instances where 91% were assigned to physical demands such as using the software outside class time since ABRA is not part of the curriculum (n=22); having plan B if technology fails (n=15) or there is no electricity (n=9); or managing technology use in big classes (n=7).

Major Challenges to Widespread Use of ABRA

Each of the 40 interviewees provided up to 18 ideas about the impediments to scaling ABRA in Kenyan schools (Table 3). Unreliable technology and infrastructure in schools (n=38) and lack of technical support at schools (n=17) were most frequently reported school-related challenges whereas rival programs and tools supported by the government (n=15) pertained to the system-related factors.

Among teacher-related challenges, the most frequently reported were technophobia and lack of ICT skills (n=29) and lack of interest in technology-based programs (n=19).

Table 3*Summary of Codes by Challenges to Scale*

Categories (Number of ideas)	Number of Sources	Number of Coding References	% of Total Coding References
<i>Total</i>	40	218	
ABRA related (3)	8	9	4.13%
School-related (20)	39	100	45.87%
System-related (9)	13	17	7.80%
Teacher-related (24)	29	92	42.20%

Political Factors

Thirty-five respondents provided between one to eight comments about political influences on viability and scalability of ABRA tools in Kenyan schools (Table 4). Curiously, teachers offered considerably fewer opinions than school administrators and partners. Of the 121 instances, 65 pertained to the positive influences whereas 56 related to the impediments. We grouped policy-related factors as related to the context for the intervention, local and national governments' engagement with the ABRA implementation, and the potential outcomes of this engagement.

Table 4*Summary of Codes by Political Factors*

Categories (Number of Ideas)	Number of Sources	Number of Coding References	% of Total Coding References
<i>Total</i>	35	121	
General educational system policies (20)	31	46	38.01
Local government (3)	14	15	12.4
Engaging government (5)	20	20	16.53
Benefits for the project (12)	29	40	33.06

According to the interviewees, the role of government for sustainability and scale of the intervention is paramount (n=20). Thus, ABRA should be part of the national curriculum (n=20), included on the Kenyan cloud, and authorized as the Digital Literacy Program content accessible on the government-provided tablets. However, some respondents (n=5) felt that government is protective of

those initiatives they have developed from the beginning. This is why building the government's trust in the value and relevancy of ABRA is critical for sustainability and scale.

Economic and Technology Factors

All interviewees commented on the potential influences of economic and technology factors (Table 5). A computer-based pedagogical intervention might be affected by the school economies such as limited school budgets to cover expenses (n=12) and ever-growing costs such as technology repairs and electricity bills (n=13). In this context, the government's funding and support towards ICT in schools is critical (n=15), as are parent contributions to school budgets (n=11). Although, funds for technology should be earmarked (n=11). Poverty as a system-related factor affecting implementation was mentioned once.

Table 5

Summary of Codes by Economic and Technology Factors

Categories (Number of Ideas)	Number of Sources	Number of Coding References	% of Total Coding References
<i>Total economic factors</i>	35	88	
System-related (5)	19	21	23.87
School-related (10)	48	67	76.14
<i>Total technology factors</i>	37	125	
Devices (10)	30	39	31.20
Infrastructure (5)	16	21	16.80
Support (8)	53	57	45.60
Modernization (4)	5	8	6.40

Perceptions about technology factors varied. For instance, student-computer ratio of three or four students per device seems to be an acceptable index of access to technology (n=13). One interviewee noted that this ratio was optimal in big classes where the teacher would be exhausted if they had to attend to each student working on the teacher's device. On the contrary, this indicator was commented as too high to adequately expose their students to the tools, suggesting that it should be one student per device (n=5).

Further, unstable infrastructure and electricity supply (n=13), and lack of peripheral devices/headphones (n=10) were most frequently reported to slow down implementation. The

respondents' opinions about technical service and maintenance available to schools were mixed: 10 respondents were satisfied whereas 12 were not happy. Limited technology support may have impacted the choices some school administration made because some kept computers in storage as they feared being personally accountable for broken devices.

School Factors

As Table 6 shows, the question about school and organizational factors stirred the most reactions (n=300). Each interviewee offered up to 15 ideas that pertained to leadership, concerted actions and coordinated activities on implementation, school-based expertise, and available technology.

Leadership was the critical factor for implementation (n=25). Encouraging ABRA instruction (n=14), visiting and observing classes (n=7), and following up when ABRA is not being used and thus applying pressure to do so (n=5) are the actions expected from the school leader. To be leaders, school administrators should not only understand the importance of technologies for teaching and learning (n=14) but they need to be trained in ABRA (n=7) and leadership strategies (n=5). Training might be a strategy to address administrators' resistance to change (n=7).

Table 6

Summary of Codes by School Factors

Categories (Number of Ideas)	Number of Sources	Number of Coding References	% of Total Coding References
<i>Total</i>	40	300	
Administration and leadership (26)	47	132	40.67
Concerted actions (23)	45	113	37.67
Scheduling (6)	20	27	9.00
Expertise (13)	25	35	11.67
Available technology (1)	1	3	1.00

It takes a whole school to implement a successful ICT programme, including a concerted effort to build ownership (n=15), collegial decision-making about its implementation (n=9), and the involvement of parents (n=16). Scheduled implementation and support activities should include uses of ABRA whether in the school lab or regular classroom (n=11), time for teachers to learn the tools (n=8),

to share (n=10), and to support each other (n=6). School-based ambassadors are noted as experts capable of adequately supporting implementation (n=16).

Professional Development Factors

Each of the 35 respondents shared up to 15 ideas about teacher professional development (Table 7). Interestingly, four respondents (not teachers) provided one-third of all comments. Training was central in the model of ABRA-related professional development (n=10). The comprehensive nature of ABRA training was noted for its potential to make up for the gaps in the Digital Learning Program (DLP) training and target multiple stakeholders involved in implementation, including school administrators (n=4) and ambassadors (n=6).

Table 7

Summary of Codes by Professional Development Factors

Categories (Number of Ideas)	Number of Sources	Number of Coding References	% of Total Coding References
<i>Total</i>	35	131	
Training: general (10)	14	19	14.51
Training: outcomes (16)	21	32	24.43
Training: modes (5)	19	24	18.32
Training: accreditation (4)	7	11	8.40
Follow-up support (14)	21	45	34.35

Respondents also commented on the content and desired outcomes from training (n=32). In addition to developing an understanding of the tool and how to use it, training emphasizes the fit between ABRA tools and other programs; training also presents the comprehensive view of ABRA teaching logic; and improves instructional flexibility and capacity to make informed decisions about the tool to use. It targets a range of broader skills, including managing group work, teaching with ICT, and reflecting on teaching.

Offering certification in ABRA pedagogy is valued (n=11) as the evidence of professional growth, as a means to promotion, with marks on teacher appraisal or as a symbolic reward. There was an expressed need for structured follow-up (n=17) with ambassadors as the critical driver (n=9). To support teachers in small schools and remote areas, building the ABRA network was suggested (n=8).

Software Factors

In regard to ABRA software, the interviewees' highlighted the unique place that it takes in the instructional landscape and, therefore, its potential to bridge the existing gaps in the curriculum (n=14). Specifically, ABRA's flexibility makes it distinct in comparison to the prescriptive approach used in previous national programs targeting foundational skills in early reading (TUSOME, in Kiswahili Let's Read). Furthermore, ABRA targets specific skills versus general nature of the traditional instruction. Finally, READS library offers a wide range of resources in English and some in Kiswahili.

Table 8

Summary of Codes by the Software Factors

Categories (Number of Ideas)	Number of Sources	Number of Coding References	% of Total Coding References
<i>Total</i>	40	235	
Bridges gaps (7)	22	14	5.96
Inadequacies (14)	25	42	17.87
Effectiveness (13)	28	42	17.88
Content (13)	22	38	16.17
Fit (7)	32	48	20.42
Design and features (19)	22	35	14.90
Student-centeredness (5)	10	16	6.81

The fit between ABRA and educational context including the Competency-Based Curriculum, its goals, and teaching schemes was reported most frequently (n=46). ABRA is well aligned with the paper-based national programs and reinforces these programs as interactive learning technology that works on the government-provided tablets. ABRA interactive content was commented to offer more than existing curricular materials and textbooks (n=21). In addition to interactivity, game-like design, potential for differentiated instruction, and interoperability of the software on various devices and platforms were notes. Student-centeredness of ABRA was important (n=10) as it supports student autonomy, enables learning at one's own pace, and teaching each other.

ABRA effectiveness was commended (n=27). The tools generate evidence of learning progress, enable teachers to motivate students, and stimulate interest yielding important learning gains. After

being exposed to the tools, younger students outperform older ones. Further, students continue to be interested in using ABRA even after they used it for some time.

Interviewees also commented about inadequacies noted in ABRA tools. They noted lack of fit with the local language context, including accent, no access to the tools from home, lack of reading activities for older students, and ambiguity in the meaning of some concepts introduced in a tool were reported.

Individual Teacher Factors

Thirty-five participants commented about the teachers who would be inclined to teach with ABRA (Table 9). Interestingly, the teacher-interviewees gave minimal opinions on the matter. Overall, the comments focused on dispositions and skills that the teacher-user of ABRA possesses.

Table 9

Summary of Codes by Individual Teacher Factors

Categories (Number of Ideas)	Number of Sources	Number of Coding References	% of Total Coding References
<i>Total</i>	35	175	
Self-determination (1)	1	1	0.57
Self-efficacy (4)	18	22	13.57
Dispositions (29)	48	104	59.43
Skills and abilities (11)	21	31	17.71
Self-efficacy sources (2)	9	9	5.14
General observations (2)	2	2	1.14
Teacher age (1)	6	6	3.43

Being the most important factor (n=29), the dispositions of the ABRA teacher include professional interest (n=12) and confidence, using ICT (n=11), ability and readiness to get out of the comfort zone (n=7), and passion (n=5). Teacher readiness to do extra work (n=6), commitment (n=3), and persistence (n=3) were also noted as drivers of sustainable use. On the opposite side of the spectrum are the teachers described as passive (n=7), technophobic (n=6), or questioning the purpose of teaching with ICT (n=3).

Contrary to the factors arising from the affective domain, teacher capacity and skills were less reported. They include ability to use ICT and integrate it in instruction (n=12), ability to train others (n=4), and self-teach (n=2). The arrival of a new generation of tech-savvy teachers was noted as a potential turning point for a large-scale acceptance of technology-based interventions (n=6).

Individual Student Factors

The comments about student factors that may affect teaching with ABRA were rare (Table 10). Only 19 respondents, either a teacher or a school administrator, expressed up to seven ideas. These rather related to the gains students got as a result of learning with ABRA tools and included the increase in student autonomy (n=10), engagement (n=9), and interest to learning (n=6). Together with improvements in student learning (n=6), progress in students' social skills, perseverance, capacity to peer-teach and even readiness to teach teachers were reported.

Table 10

Summary of Codes by Individual Student Factors

Categories (Number of Ideas)	Number of Sources	Number of Coding References	% of Total Coding References
<i>Total</i>	<i>19</i>	<i>70</i>	
Disposition (6)	11	16	22.86
Skills and abilities (9)	13	16	22.86
Benefits for students (7)	23	38	54.29

Some respondents stated that weaker students required more time to learn with the tool. Others suggested that student individual differences did not matter, instead it is the teachers' capacity to implement the tool that counts (n=3). At the same time, successful ABRA students are tech savvy and excited by ICT (n=11).

Factor Effects

We also investigated what factors might have influenced the teachers' intent to continue or stop using ABRA in their practice. First, we applied the expectation-value framework which reduces teaching with technology to a simple teacher motivation equation (Wozney et al., 2006). The composite variable of the teacher Motivation to Sustain ABRA Use was created by aggregating the number of coding references within each of the three categories of value (M=3.05, SD=2.22), expectations

($M=2.75$, $SD=1.90$), and costs ($M=2.13$, $SD=1.59$) per respondent and letting them enter the equation expectancy + value - cost of use. The resulting motivation mean score and the standard deviation were 5.25 and 3.76 respectively (Table 11).

We calculated continuous composite scores for the eight factors by combining together the subcategories within each factor. We hypothesized that the factors directly predict practitioner's intent to continue or stop using ABRA. Additionally, we assumed that Teacher Factors can be directly predicted by Professional Development, Student, and School Factors and serve as an intervening variable between the three sets of factors and teacher motivation to sustain the ABRA Use. The correlation coefficients support this assumption (Table 11) showing significant positive relationship between a) PD, School Factors, and Teacher Factors, and b) Teacher Factors, PD, School Factors, and Motivation to Sustain ABRA Use.

Table 11

Means, Standard Deviations, and Correlations of Eight Factors and Motivation to Sustain Using LTK

	1	2	3	4	5	6	7	8	M	SD
1. Motivation to sustain use of LTK									5.25	3.76
2. Economic Factors	.154								2.20	1.85
3. Technology Factors	.092	.462**							2.90	2.45
4. Political Factors	.231	.070	.302						1.85	1.61
5. Software Factors	.107	-.025	.208	.204					5.55	3.49
6. School Factors	.322*	-.124	-.109	-.113	.141				7.30	3.81
7. PD Factors	.363*	.017	.039	-.011	.047	.297			3.15	3.11
8. Teacher Factors	.351*	-.058	.254	-.018	.096	.483**	.444**		4.33	3.94
9. Student Factors	.297	.068	.092	-.051	.066	.111	.009	.449**	0.65	0.98

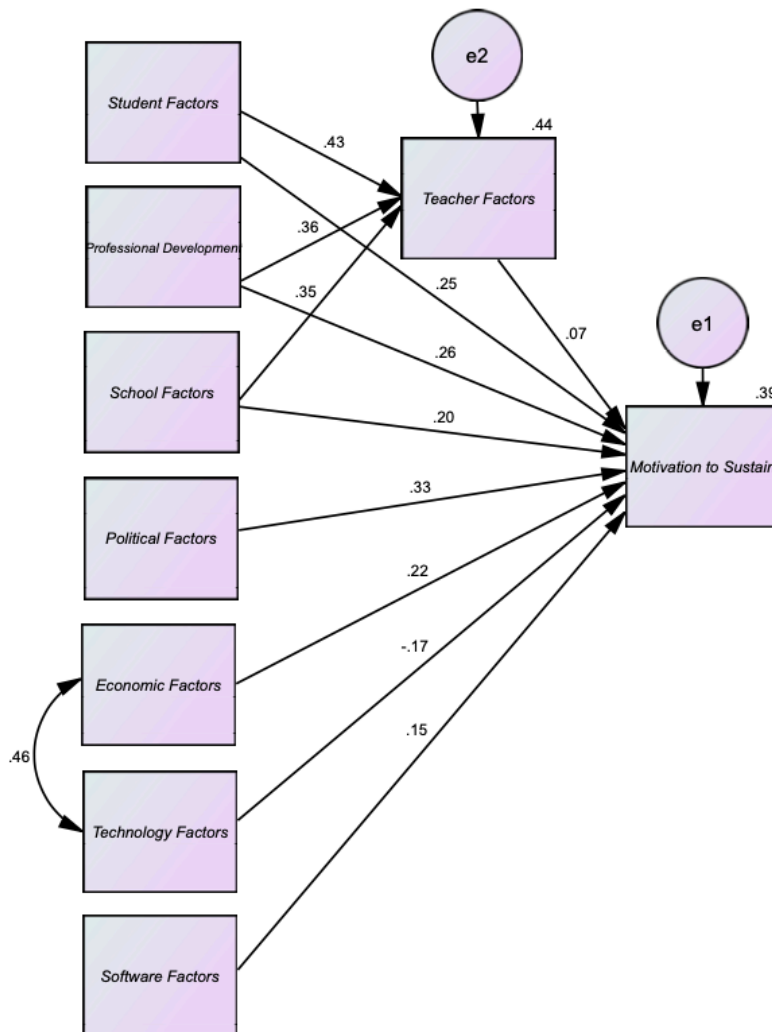
Note. ** $p < 0.01$; * $p < 0.05$

AMOS path analysis generated support for the hypothesized model with the chi-square index of 25.905 ($df=24$), $p=.358$. The Goodness-of-fit indices also implied a reasonably well-fitting model. The Comparative Fit Index (CFI) of 0.96 was robust. The Root Mean Square Error of Approximation index (RMSEA) was 0.045 ($p=.458$) with the confidence intervals of 0.000 and 0.140. Such combination of RMSEA and confidence intervals suggest an acceptable precision of the model. There was no evidence of the model misfit. Two modification indices ($MI < 20$; parameter change $< .10$) suggested that the

hypothesized model is appropriately described; the highest standardized residuals was 1.88 below critical value of 2.58. The hypothesized model is in Figure 2; the model effects are in Table 12.

Figure 2

Effects on Teacher Motivation to Sustain Use of LTK Path Model



The eight factors accounted for 39% of the variance in the motivation to sustain ABRA use. The effects of the seven exogenous factors within the model were mixed. Increased motivation to sustain the use of ABRA was significantly predicted by Policy and Professional Development Factors, the standardized coefficients were 0.34 and 0.27 respectively, whereas the remaining five factors did not have significant direct effects.

Table 12*Decomposition of Effects*

	Factors							
	PD	Student	School	Teacher	Political	Economic	Technology	Software
Standardized direct effects								
<i>Teacher Factors</i>	0.359*	0.431**	0.355*					
<i>Motivation to Sustain ABRA Use</i>	0.265*	0.245	0.204	0.065	0.335*	0.220	-0.172	0.151
Standardized indirect effects								
<i>Motivation to Sustain ABRA Use</i>	0.023	0.028	0.023					
Standardized total effects								
<i>Motivation to Sustain ABRA Use</i>	0.288*	0.274*	0.227	0.065	0.335*	0.220	-0.172	0.151

Note. ** $p < 0.01$; * $p < 0.05$

Except Technology Factors whose effect was negative, the other factors' influences were positive. Student, School, and Professional Development Factors each had a strong direct significant effect collectively explaining 46% of variance of the only moderator, Teacher Factors. The respective coefficients were 0.43, 0.35 and 0.39. Yet, Teacher Factors minimally contributed to the variation in a teacher's intent to sustain the ABRA use ($\beta=0.065$). After controlling for the mediator, the indirect effects of the Student, School, and Professional Development Factors on the intent to sustain use were positive but small and not statistically significant. The total effects were statistically significant for Political, Professional Development, and Student Factors implying that each one-point increase in reporting them would rise motivation by 0.34, 0.29 and 0.27 per unit respectively. Except for the strong and significant relationship with Teacher Factors, School influences were not significant for the Motivation to Sustain the Use of ABRA; neither were Economic, Technology and Software Factors.

Discussion

This paper reports the findings from the interviews of 40 schoolteachers and headteachers, and partners involved in implementing the ABRA. We explored their perceptions and experiences about the factors believed to influence adoption and further use of this educational technology. The individual teacher's agency in making the difference in the classroom, the school, and eventually, the whole system is the cornerstone of this study. However, implementing an innovation with quality and efficiency, and then sustaining it and, eventually, bringing it to scale, are subject to many challenges and opportunities. In our model, three set of influences, Political, Teacher Professional Development, and Student Factors, accounted for the teachers' self-reported intent to teach with ABRA.

Political context shaped by government, unions, parents, and other interest groups turned out to be the most influential antecedent for the teachers' decision to implement and sustain the program. In this regard, it was critical to demonstrate to teachers how ABRA fits the educational landscape and helps achieve national educational objectives brought in by the massive curricular reform and the technology initiative (DLP). More efforts are yet to be made in order to build the government's trust in the value and relevancy of ABRA, which is critical for the program sustainability and scale.

Professional Development Factors had important effects on teacher motivation, skills, and dispositions. Participation of expert users of ABRA such as trainers and school-based ambassadors in the system of training and follow-up support benefited teachers and, especially, neophytes. Expert users modelled ABRA for school contexts and addressed the uncertainties of those just starting out by illustrating experts' success in beginner-like contexts. In addition to experts, teachers gained from peer learning where they planned ABRA instruction, shared experiences, and reflected upon them. Since formal ABRA certification helped the progression of teacher career, it contributed to their motivation too. Yet, it also might be that teachers saw TPD as an opening to escape drudgery of their classrooms.

The influence of Student Factors was important on teacher motivation. Students' experiences with the software increased their autonomy, engagement, and interest in learning drove their teachers' enthusiasm and intent to continue using the tool. Further, students' vocal support of using the software for teaching might have prompted teachers to improve their capacity and effort to integrate ABRA in instruction.

Despite the important contribution from students, professional development opportunities and school environment in teacher factors including skills and competencies, the effect of Teacher Factors on motivation to sustain teaching with ABRA was non-existent. Indeed, skills and competencies can potentially drive changes in practice but only to a limit. Salinas et al. (2017) suggest that while many teachers become involved in innovation because they feel their personal effort is worthwhile regardless of whether they receive support from the system, yet a longstanding change cannot be maintained through teacher commitment alone. For if the effort must be sustained for too long, it is likely that the enthusiasm of these teachers will wain and they will no longer be able to sustain a complicated process of the innovation use. As a result, teachers may assign greater importance to the centralized system and its policies, rather than their own capacity and skill. We can only speculate that the important weight assigned to policy factors and lack of weight assigned to teacher factors in the teacher intent to implement ABRA reflects the tension between external and internal agency needed to drive change in teacher practices.

Conclusion

The usefulness of these findings is three-fold. First, these results are practical in the context of developing countries where little is known about the evidence-based principles of building sustainable and scalable educational interventions (Robinson et al., 2017). The existing research tends to follow the evolution of relatively large initiatives into educational mainstream while learning about how a small intervention proven successful with a handful of teachers and students can grow to reach many in dire need of it stirs less interest in educational development research. Second, the tested model validated the results from the qualitative interviews, suggesting paths associating a range of external and internal factors with teacher motivation to implement ABRA. Yet, it is also likely that other factors not included in this model, such as measurement error, coder bias, and small sample size, had their effects. Third, the model points to the priority directions for technology-based pedagogical innovations to endure and expand in developing contexts. This includes seeking instrumental support from the local and national stakeholder agencies and enhancing teacher professional development in order to strengthen individual and collective teacher capacity.

Finally, since spreading beyond a few schools raises strategically different issues for the project, the results of this study suggest the need to advance our research agenda. For instance, further validation

of the model is important. Hence, a pool of around 500 teachers who either continue or stopped teaching with ABRA could be targeted by an online close-ended survey based on this interview. Substantially, it is necessary to learn how we could effectively thread the ABRA-related ideas throughout the local and national educational authorities to establish their long-term support and ensure that the activities fit the short- and long-term strategies of these authorities even if their priorities change. To this end, it is also important to build the cost-effective TPD and support system as the critical multiplier to scale the ABRA program. After all, in the constraints of low- and medium-income contexts, the practical value would be assigned to an innovation when it functions at minimal costs without losing its impact on teacher practices and student learning.

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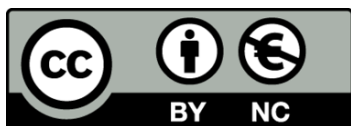
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